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THE ECONOMIC VALUE OF REMOTE SENSING OF EARTH RESOURCES FROM SPACE: AN ERTS OVERVIEW AND THE VALUE OF CONTINUITY OF SERVICE

VOLUME VI

LAND USE

PART I:

INTRODUCTION AND OVERVIEW

Prepared for the
Office of the Administrator
National Aeronautics and Space Administration
Under Contract NASW-2580

October 31, 1974
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ECONOMICS, OPERATIONS RESEARCH, SYSTEMS ANALYSIS, POLICY STUDIES, TECHNOLOGY ASSESSMENT

NOTE OF TRANSMITTAL

This resource management area report is prepared for the Office of the Administrator, National Aeronautics and Space Administration, under Article I.C.1 of Contract NASW-2580. It provides backup material to the Summary, Volume I, and the Source Document, Volume II, of this report. The interested reader is referred to these documents for a summary of data presented herein and in the other resource management areas.

The data presented in this volume are based upon the best information available at the time of preparation and within the resource of this study. This includes a survey of existing studies plus Federal budgets and statutes. Throughout the analysis, a conservative viewpoint has been maintained. Nonetheless, there are, of course, uncertainties associated with any projection of future economic benefits, and these data should be used only with this understanding. ECON gratefully acknowledges the contributions of Keith R. Lietzke and Peter A. Stevenson who authored this volume.

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ABSTRACT

This study analyzes the utility of an ERS system as an effective tool in Land Use management. The approach taken here divides the analysis into two parts, 1) a qualitative study of potential Land Use resource management functions (RMF's) (Part I), and 2) a cost effectiveness comparison between alternative Earth Resource Survey (ERS) systems based on various projected levels of demand (Part II). The study of ERS information as applied to Land Use management is a relatively new field. As a result, the primary purpose of Part I is to explore this new area by qualitatively examining the potential new capabilities a spaced-based ERS system could offer the Land Use manager. A variety of RMF's are postulated within which ERS activities might occur and the present ERTS investigations in these areas are outlined.

The second part of this volume addresses the issue of the cost effectiveness of satellites as a component of an ERS system. This study contains an estimate of the Federal legal and statutory requirements for remote sensing as they form a lower-bound estimate of the demand for remote sensing. The study indicates a cost savings potential of from $7.9 to $37.1 million annually attributable to the inclusion of ERTS-like satellites in the ERS system.

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1.0 INTRODUCTION AND OVERVIEW: LAND USE

Land use planning is a discipline whose importance has been rapidly growing over the last few years. Partly as an outgrowth of the increasing environmental awareness recently seen in this country, the necessity for effective management of land use has been underscored by three long-run trends in our society:

1) Increased population combined with a somewhat abrupt end to the American frontier has led to increased population density in almost every state, region and city in the country;

2) Increased mobility, be it resulting in crosstown shopping trips, into-the-city commuting to work or cross country vacation trips, has effectively led to a further increase in density -- we share more territory because we have access to more territory;

3) Increased economic productivity has led to an increase in consumption (consumption which, inherently, causes increased wastes) while at the same time yielding more free time resulting in increased demand for leisure and recreation services, both of which are highly dependent on environmental quality.

These trends have resulted in the single cause necessitating land use planning: competing and conflicting demand for land. The pricing mechanism may not always represent legitimate demands for a parcel of land. For example, within a residential section, an industrial firm may have more purchasing power for a property than a would-be resident. Yet the price which the would-be resident can offer does not fully reflect the added benefit which neighbors would receive in having a house and not a factory next door. Traditionally, this problem has been locally handled by zoning laws. However, zoning laws are inappropriate for dealing with larger-scale, urban or regional planning. State authorities might feel that the agricultural resources of the state offer benefits worth preserving and thus they might wish to inhibit residential encroachment into farmlands. Or forests may provide habitat for wildlife and human recreation, and thus that land may be preserved over other uses.

Besides management demand arising from the fact that the market pricing structure does not reflect externalities in demand (e.g., the preferences of others in a neighborhood), there is further need for a land use management authority: to collect and disseminate information whose absence leads to inefficient resource allocation. An obvious function here might be the mapping of flood plains which might keep houses from being built in a flood plain area.

Mismanagement and lack of management of land has caused problems with which we are all familiar. Cities are frequently so intensively urbanized that there is no access to parking areas for many of their residences. Certain highway systems have unnecessarily hurt social and environmental order and provide more confusion than service. In central New Jersey (Plainfield), a flood area developed as a result of excessive land development. An area that never flooded in the past now suffers frequent flooding.

Optimal land use management occurs when there exists a minimum of conflicting demands for an area. This is possible when demands are not *constricted* but *directed*. If an industry has located along a waterway because it yields a cost advantage used as a coolant and as a waste dispersal mechanism, large inefficiencies occur when legislation is passed which prohibits pollution of the waterway for aesthetic purposes. Early recognition that the building of a factory would conflict with other demands would have led to superior allocation of the capital resources.

In order to avoid conflict, land use trends must be detected and demand must be anticipated; this requires the best of real-time data. Land use and land use change maps provide the basic data sources from which planners work. But the frequent update of these maps is prohibitively expensive, and thus there arises demand for satellite data. While needing a large initial investment, satellites offer coverage at very low incremental cost. The greater the frequency of coverage and the area of coverage needed, the higher will be the demand for satellite information.

ERS data will find important application in land use classification although there will be some capability in land use suitability. The Inter-Agency Steering Committee on Land Use Information and Classification has emphasized a need for standardization of classifications and proposed the following two levels for use with remote sensed data.* There exists a total of four levels of classification Level I (scale of 1:1,000,000 to 1:250,000) had been intended for satellite sensing and Level II (1:100,000) for high altitude aircraft.

Investigators have found that all Level I and II land use categories with the exception of Level II-Institutional can be delineated. Investigators have differed in the number of categories detected from 6 Level I elements (Henry, Alabama) to 34 categories, 7 Level I, 16 Level II and 11 Level III (Sizer, Minnesota).** (Two Level I categories - Tundra, and Permanent Snow and Ice Fields - have not been detected in any of the test sites as the test site latitudes have been too low).

Table 1: Land Use Classification System for Use With Remote Sensor Data

Level I	Level II
01 Urban and Built-up	01 Residental
	02 Commercial & Services
	03 Industrial
	04 Extractive
	- Major Transport Routes & Areas
	Institutional
	6. Strip & Clustered Settlement
	08 Mixed
	09 Open & Other
02 Agricultural	01 Cropland & Pasture
	02 Orchards, Groves, Bush Fruits, Vineyards & Horticultural Areas
	03 Feeding Operations
	04 Other
03 Rangeland	01 Grass
	02 Savannas (Palmetto Prairies)
	03 Chaparral
	04 Desert Shrub
04 Forestland	01 Deciduous
	02 Evergreen (Coniferous & Other)
	03 Mixed
05 Water	01 Streams & Waterways
	02 Lakes
	03 Reservoirs
	04 Bays & Estuaries
	05 Other
06 Non-Forest Wetland	01 Vegetated
	02 Bare
07 Barren Land	01 Salt Flats
	02 Sand (Other than Beaches)
	03 Bare Exposed Rock
	04 Beaches
	05 Other
08 Tundra	01 Tundra
09 Permanent Snow & Ice Fields	01 Permanent Snow & Ice Fields

* "A Land Use Classification System for Use with Remote-Sensor Data," Anderson, Hardy, and Roach, Geological Survey Circular 671, 1972.

** Sizer and Brown, "ERTS-1 Role in Land Management and Planning in Minnesota", <u>Third ERTS Symposium</u>, NASA, December 1973, p. 341

The following is a list of land use categories detected in ERTS-1 imagery which are not in Levels I and II of classifications in the U.S.G.S. Circular:*

Table 2: List of ERTS-1 Detected Land Use Categories Not in Levels I and II

• Mobile Homes	• Agricultural (plowed)
• Parking Lots	• Agricultural (non-plowed)
• Unimproved Open Space (bare)	• Extractive (mines)
• Improved Open Space (irrigated)	• Extractive (tailing pipes)
• Unimproved Open Space (with trees)	• Extractive (basins)
• Low Density Residential	• Extractive (gravel pits)
• High Density Residential	• Sanitary Land Fill
• Developed Open Space (urban)	• Water (natural basin)
• Rural Open Land	• Water (excavated basin)
• Right-of-Ways in Forest	• Wetlands (Northern Bogs)
• Rural Settlements	• Wetlands (Southern Perennial)
• Wooded Rangeland	• Wetlands (Southern Seasonal)
• Soybeans	• Low Income Residential
• Corn	• Middle Income Residential
• Exposed Soil	• Coastal Strand
• Winter Ryegrass	• Coastal Salt Marsh
• Stubble	• Coastal Sage
• High Density Single Family	• Woodland Savannah
• Low Density Single Family	• Riparian Vegetation
• Mixed Multiple and Single Family	

The threshold of resolution is 10 acres for comprehensive land use mapping and 2 to 5 acreas for some specific categories. However, linear features as small as 16 meters across have been detected.

The Principal Investigators, in many cases, have worked in conjunction with a variety of state and regional user agencies. Whereas there is much variation in the apparent capabil-

* "Analysis of Costs and Benefits from Use of ERS Data in State and Land Use Planning," EarthSat Interim Report for the Dept. of Interior, Contract No. 14-08-001-1359, May 1974, p.58.

ities of ERTS-1 and data processing procedures, Joyce has outlined four categories of data use for ERTS-1 imagery:*

"Baseline data on the use of land for the most part, baseline information presented on maps and/or in statistical form, is used indirectly by administrators, managers, and legislators in a manner such that specific data cannot be traced to a specific action. For example, if a legislator knows that 10 percent of the land in the state is in the wetlands category (versus not having any information on the extent of wetlands), this information would be useful in considering wetlands legislation, but the exact manner in which such information is used varies. The potential use of baseline information derived from ERTS data varies from a high degree in areas where recently acquired land use information existed at the time that FRTS-1 was launched.

"Baseline data update-Updating serves two purposes: First, it keeps the data base current and meaningful, and second, it adds another dimension of information by documenting the extent of change during a time period and/or monitoring change through a time period. For example, it would be meaningful for a legislator to have information about the extent of wetlands, but it would be even more meaningful to know the rate at which the wetlands areas are diminishing. The actual and potential use of ERTS data for updating depends on the rate of change taking place in a given area, the alternative sources of current data, and the detail in the original data base. Most investigators are enthusiastic about the potentials of ERTS data for updating, but they have not yet pursued update activity to any significant extent because their first concern has been to establish interpretation and data handling procedures.

"Information management system-Information derived from ERTS data as one data component of a data bank has received considerable attention. Most land use investigators realize that meaningful decisions in land management and/or land use planning cannot be

* Joyce, A.T., "Land Use and Mapping," Third Earth Resources Technology Satellite Symposium, Vol. III.

made until da on the actual use of land can be integrated with other data, such as data on environmental factors, economic factors, and ownership. Once various sources of data have been combined to indicate land suitability or land capability, this information can be compared with the actual use of the land."

"Operation of models-A strict definition of a land use model would incorporate the five following components:

1. Acquisition: Data are acquired and manipulated into a useful information format to be supplied as a base for the model.

2. Simulation: The information is then used to simulate a real, ongoing process.

3. Projection: A certain policy, decision, or course of action is then provided to the model.

4. Prediction: The model then accepts the course of action, operates with the information, and then attempts to predict a future or past state.

5. Output: The information is displayed or presented in a form that is meaningful to a decision-maker."

The purpose of this volume is to determine the potential for an ERS satellite system in Land Use. The approach used is to identify the statutory demand for Land Use remote sensing activities and qualitatively define or explain the specific activities (in RMF's) which this demand encompasses. The RMF overview (Part I) attempts to provide a broad list of Land Use functions where remote sensing might be advantageous. The particular way in which satellites might be effectively employed is outlined and economic benefits explained where different from cost savings over the other data collection systems. The ECON Land Cover Case Study* (Part II) quantifies existing statutory demand to Level II Land cover data and projects likely demand levels in the near future, 1977 and 1985. The Case Study then

* "The Role of ERTS in the Establishment and Updating of a Nationwide Land Cover Information System," prepared for NASA, Office of Applications by ECON, NASW-2558, August 31, 1974. (Part II of Volume VI of this study).

derives a cost comparison between three different approaches for satisfying this demand. The costs of using (1) satellite/high altitude aircraft/ground truth; (2) high altitude aircraft/ground truth; and (3) ground truth systems are documented for different demand levels and for different allowable cloud cover levels. Cost savings accruing to a satellite system (assuming that statutory demand is met) are summarized in Figures 1 and 2 and Tables 3 and 4.

Figure 1 illustrates the cost efficiency frontier for land cover information systems as a function of demand, with allowable cloud cover of 0-30%. As shown, a "without satellites" system (HA/GT) is cost effective up to a demand level of about 5 times full U.S. coverage per year; a two satellite system is least expensive at demand levels exceeding 5.0 and a three satellite system above (.5. A change in the allowable cloud cover to 10% maximum increases the coverage necessary to achieve each demand level. As shown in Figure 2, the first cost-effective "with" system is a three satellite system at a demand level of 5.

Tables 3 and 4 show cost savings accruing to a satellite system as a function of demand and allowable cloud coverage. Benefits (for Federal land cover alone) from a more cost-effective land cover system range from 7.9 to 17.0 million dollars annually at 30% cloud cover and from 21.0 to 37.1 million dollars annually at 10% cloud cover.

The Earth Satellite Corporation undertook a similar study as an extension. Their study involves an analysis of state demand for land use data which could be satisfied by an ERTS-like system. This study performed a similar cost-effectiveness analysis, comparing a without-ERTS satellite system to a with-ERTS satellite system in satisfying state demand for land use data. Table 5 presents a summary of the findings of the EarthSat study.*

Benefits from the two studies cannot be algebraically summed. Much of the coverage necessary to fill Federal statutory demand would be sufficient for meeting many state coverage requirements. Thus a summation would be an over-

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* Figure II-16, "Analysis of Costs and Benefits from Use of ERS Data in State Land Use Planning," EarthSat Interim Report for the Dept. of Interior, Contract No. 14-08-001-1359, May 1974, p. 94.

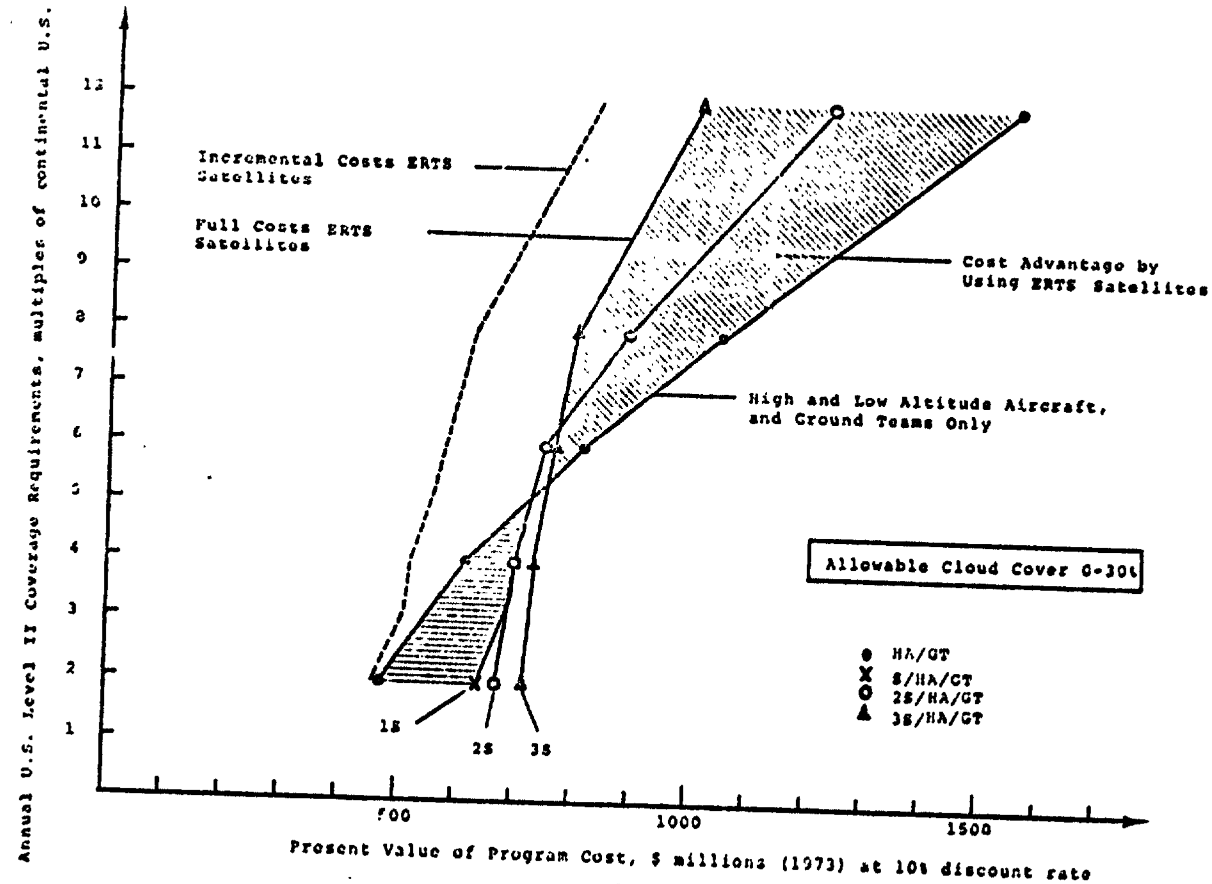

Figure 1: The ERS Cost Efficiency Frontier (0-30% Cloud Cover)

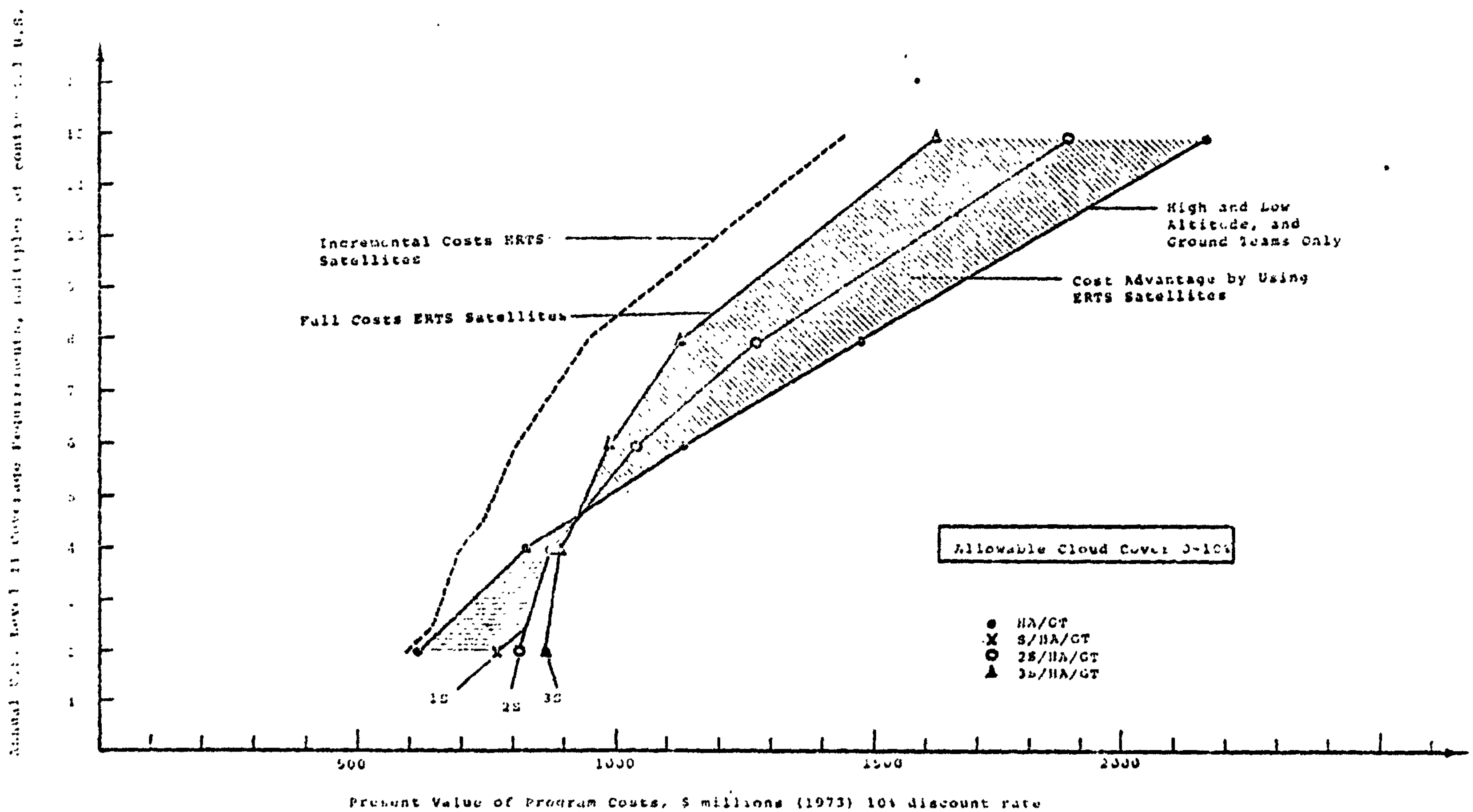

Figure 2: The ERS Cost Efficiency Frontier (0-10% Cloud Cover)

Table 3: Discounted Total Program Cost (1977-1993) to Satisfy the Projected Future Nationwide Demand for Land Cover Information -- Level II Information -- Automatic Data Processing -- Allowable Cloud Cover (0-30%)

Projected Level II Demand	Program Costs, $ millions (1973) discounted at 10% to 1974			
	All Aircraft System	Lowest Cost With Satellite System	Net Present Value	Equivalent Undiscounted Annual Cost Savings 1977-1993
1977-1993 Six times at 60 days	815.9 HA/GT	758.4 2S/HA/GT	57.4	7.9
1977-1984 Six times at 60 days 1985-1993 Eight times at 45 days	892.3 HA/GT	797.4 2S/HA/GT	94.9	13.0
1977-1980 Six times at 60 days 1981-1993 Eight times at 45 days	954.2 HA/GT	829.9 2S/HA/GT	124.30	17.0

Table 4 Discounted Total Program Cost (1977-1993) to Satisfy the Projected Future Nationwide Demand for Land Cover Information -- Level II Information -- Automatic Data Processing -- Allowable Cloud Cover (0-10%)

Projected Level II Demand	Program Costs, $ millions (1973) discounted at 10% to 1974			
	All Aircraft System	Lowest Cost With Satellite System	Net Present Value	Equivalent Undiscounted Annual Cost Savings 1977-1993
1977-1993 Six times at 60 days	1137.6 HA/GT	984.4 3S/HA/GT	153.1	21.0
1977-1984 Six times at 60 days 1985-1993 Eight times at 45 days	1251.0 HA/GT	1032.5 3S/HA/GT	218.5	30.0
1977-1980 Six times at 60 days 1981-1993 Eight times at 45 days	1342.7 HA/GT	1072.0 3S/HA/GT	270.7	37.1

Legend:
S refers to an ERTS type satellite
HA refers to high altitude aircraft (U2)
GT refers to low altitude aircraft and ground survey follow-up teams

Table 5: Summary of Estimated Equilibrium Benefits in State Land Use Planning Using ERS Data		
Assumption	Present Value 1977-1986, $ millions	Annualized $ millions
Constant Coverage Perfectly Inelastic Demand	51	8.3
ERS Cost Reduction Effects, Downward Sloping Demand	68	11.0
Constant Budget	98	15.9

Source: "Analysis of Costs and Benefits from Use of ERS Data in State Land Use Planning," EarthSat Interim Report for the Dept. of Interior, May 1974.

statement of total benefit. However, coverage costs would also be double-counted between the two studies, so there is no way to arrive at a total benefit figure without breaking down the two studies to remove overlaps.

It should be mentioned here that the results of the ECON case study provide cost effectiveness justification for an ERS satellite system. Thus other parts of this report (Volumes III-V, VI-X) consider only the marginal cost of additional coverage information and data processing for an ERS system in comparison with average high altitude aircraft costs when arriving at cost savings estimates. As part of the ECON Land Cover case study these costs have been identified and are presented in Table 6.

Part I (Appendix A) of this volume summarizes specific ERS functions and present capabilities. A satellite system has been found to contain significant cost savings value in mapping small scale (up to Level II) features. In general, urban, regional, and private demands cannot be satisfied by the resolution capabilities of existing civilian systems. These demands appear to be very large, although very diffuse and unquantified, and there exist substantial benefit potential for an ERS system with higher resolution capabilities. RMF 4.4.3, in particular, contains a technique for utilizing land use and physical characteristics maps in land management decision-making. The methodology of Ian McHarg, who uses thematic maps of a region on transparent plastic sheets, is described here. McHarg uses these sheets in highway planning and demonstrates how graphic representation of social values in a region can greatly aid planning projects. This technique should find great value and application in many site selection activities. ERTS-1 capabilities have been shown to be particularly advantageous in detecting subtle, small-scale features, such as potentially dangereous faults and lineaments. Besides cost-savings, ERTS offers difficult-to-match frequency of coverage and highly interpretable readout in near real time.

Table 6 Cost of Land Cover Information (dollars per square mile)

	Satellite	Manual Aircraft	Ground	Satellite	Automatic Aircraft	Ground
Level I	.34	1.13	11.0	.048	.80	11.0
Level II	NC	1.60	12.5	.194	.97	12.5
Level III	NC	NC	14.6	NC	1.42	14.6

NC- The sensor is incapable of providing the required detail.

Table 7 summarizes Federal statutes that form a basis for the legal-statutory demand for ERS satellite data in each of the RMFs discussed in this volume.

Table 7: Federal Statutes in Support of Resource Management Function: Land Use

Resource Management Function	Applicable Federal Statutes
4.1 Cartography, Thematic Map and Visual Displays	
4.1.1 Cartography and Thematic Map Making	43 USC 31
4.1.2 Land Use Maps of the United States - Federal and State Levels	P.L.92-419, 7 USC 1010, 7 USC 427-427i, 43 USC 31, 43 USC 2, 42 USC 410L-2, P.L.90-448-Title XIII, 42 USC 4102, P.L. 90-448-Title VI, 40 USC 461
4.1.3 Fault Zone and Lineament Mapping	
4.2 Statistical Services	
4.2.1 Provide Census Estimates - Demographical Services	7 USC 427-427i, 16 USC 742 40 USC 204, 16 USC 567A, 42 USC 410L-2, P.L.90-448 Title XIII, 42 USC 4102, P.L.90-448 Title VI, 40 USC 461, 16 USC 1001-1009, 33 USC 883E
4.2.2 Regional and Local Land Use Inventories	
4.2.3 Land Use Change Statistics	7 USC 427-427i, 43 USC 31
4.2.4 Monitor Land Movements - Sand dunes, Wetlands, etc.	16 USC 1301
4.4 Allocation	
4.4.1 Selection of Federal and State Parks and Recreation Areas	P.L.90-448 Title VI, 40 USC 461, 16 USC 1001-1009, P.C. 86-645 Title VII, 33 USC 709a 42 USC 1962 A-1, P.C. 89-80
4.4.2 Location of New Towns and Other Development	
4.4.3 Allocation of Land for Highways and Other Rights-of-Way	
4.4.4 Selection of Areas for Land Reclamation	
4.4.5 Site Location of Airports and Other Major Transportation Modes	

Table 7: Federal Statutes in Support of Resource Management Function: Land Use (Continued)

Resource Management Function	Applicable Federal Statutes
4.5 Conservation	
4.5.1 Protection of Agricultural and Forest Lands	P.L.92-419, 7 USC 1010, 43 USL 315a-315f, 43 USC 1181 16 USC 1301. 16 USC 742
4.5.2 Protection of Wilderness Areas	
4.6 Damage Prevention and Assessment	
4.6.1 Map Sink, Landslide and Other Hazardous Areas and Assess Damages	P.L.90-448 Title VI, 40 USC 461, P.L.92-367, 16 USC 1001-1009, P.L.66-645 Title II, 33 USC 709a
4.6.2 Assess Impact of Earthquakes and Volcanic Eruptions	
4.9 Administrative, Judical, and Legislative	
4.9.1 Manage Federal Revenue Sharing Programs	
4.9.2 Regulate Land Use in Areas of Critical Environmental Concern	P.L.88-577, 42 USC 410L-2, P.C.90-448 Title XIII, 42 USC 4102
4.9.3 Regulate Land Development Projects	
4.9.4 Management and Plan Federal, State and Local Taxation	
Undiscounted Annual Cost Savings Benefits 1977-1993, from ERTS-like ERS in meeting Federal Statutory Demand, $ millions (1973)	7.9-37.1

APPENDIX A:

DETAILED EXAMINATION OF BENEFITS BY RMF

Appendix A contains the detailed examination of each of the Resource Management Functions of the resource area, Land Use.

RMF No. 4.1.1

CARTOGRAPHY AND THEMATIC MAP MAKING

Rationale for Benefits

Accurate and up-to-date maps serve a great variety of purposes. Terrain mapping is invaluable for many construction and engineering purposes. Worldwide mapping of land use patterns would contribute substantially to our fund of information about those countries and areas on which statistics are either totally lacking, incomplete or not regularly published. It would also serve to corroborate published statistics to determine their accuracy and reliability. Identifying and measuring urban and suburban areas would be useful. Time sequenced images of those areas will yield information on trends and changes in local populations and urbanization.

Federal Government Activities and Responsibilities

Under Statute 43 USC 31, the Department of the Interior through the Geological Survey, "shall have charge of the classification of the public lands and examination of the geological structure, mineral resources and products of the country. The survey shall examine the geological structure, the mineral resources, and the products of the rest of the world where determined by the Secretary of the Interior to be in the national interest."

Functions of Remote Sensing

Satellites offer the capability of covering large areas in very short time and at very low marginal cost. Frequency of coverage allows detection of short term phenomena, such as floods or seasonal land use changes as well as providing a near real-time update capability.

Current ERTS Activities

ERTS can determine general terrain classifications, such as mountains and rivers, flat lands, agricultural and urban areas.

RMF No. 4.1.1

Estimate of ERTS Economic Capabilities

Benefit exists in providing information more rapidly than alternative sources. Cost savings versus aircraft for mapping foreign countries run about one dollar per square mile mapped. Further benefit from increasing supply of information exists (assuming some demand elasticity does exist), but has not been estimated.

RMF No. 4.1.2

LAND USE MAPS OF THE U.S. - FEDERAL AND STATE LEVELS

Rationale for Benefits

The compilation of land use maps of the U.S. is an important activity, carried out at present by various means. An indication of its importance is given by the number of Federal statutes concerned (see below). Some land use mapping activities relate specifically to agriculture, forestry and mineral resources, respectively. They, and the benefits accruing from them, are discussed under the appropriate Resource Areas.

Land use mapping of urban areas, more properly the subject of this RMF, is generally done at the State, regional and local levels. T e applications of these maps are various, the principal being urban planning. Other applications are: taxation, enforcement of zoning and other land use laws, collection of census and statistical data, etc.

The benefits due to the availability of such land use maps accrue to their users. These benefits are accounted for in those RMF's whose activities require land use maps. They should thus not be listed under this RMF, since this would be double-counting.

There are some benefits to other miscellaneous non-government users of such maps in business, industry, education and research.

Federal Government Activities and Responsibilities

Federal statutes relating to the preparation of land use maps are numerous. The following constitutes a fairly comprehensive list:

Rural Development Act of 1972 (Bankhead-Jones Farm Tenant Act, as Amended), PL 92-419, 7 USC 1010. The Department of Agriculture "is directed to carry out a land inventory and monitoring program to include...studies and surveys of erosion and sediment damages, flood plain identification and utilization, land use changes and trends, and degradation of the environment resulting from improper use of soil, water and related resources. The Secretary shall issue at... 5-year intervals a land inventory report reflecting soil, water and related resource conditions." This act relates principally to agriculture. It is discussed in detail in the corresponding volume.

RMF No. 4.1.2

Agricultural Research Act 7 USC 427, 427i. This act is concerned with use of land and other resources for agricultural purposes. It is also discussed under Agriculture.

43 USC 31 is concerned with mapping of geological structure and mineral resources. Cited in RMF 4.1.1 and discussed more fully in the volume on Mineral Resources.

43 USC 2 is concerned with the sale of public lands of the U.S.

National Flood Insurance Act of 1968, 42 USC 410L-1, PL 90-448, Title XIII; and 42 USC 4102 are concerned with the identification and study of flood areas and flood risks, discussed in RMF 4.9.2.

The Housing Act of 1954 as amended, PL 90-448, Title VI, 40 USC 461. The Secretary of HUD is authorized to provide technical assistance to local governmental planning agencies and to make studies and publish information on related problems dealing with urban planning.

This is a primary source of funding for land use mapping programs by state and local planning agencies. Remote sensing is used extensively in these programs. A strong input by ERTS plus an increase from the present level is anticipated through 1977.

Non-Federal Activities

Many states have extensive efforts in Land Use mapping. While some of these efforts are concerned with agriculture, the populous and densely populated states are actively engaged in mapping their urban areas. Several states have comprehensive land resource inventory programs, such as New York's LUNR land use map and information system. EarthSat Corporation, in its study on State ERS activities related to Land Use,* has compiled a catalog of all efforts and levels of activity by State**.

EarthSat; "Interim Report: Analysis of Costs and Benefits from Use of ERS Data in State Land Use Planning", for USDI, USGS, March 1974.

** Op.cit., Appendix C, State ofiles

RMF No. 4.1.2

Functions of Remote Sensing

Remote sensing can provide wide area coverage at very low cost. Frequent coverage and rapid data acquisition are also valuable capabilities. The ERTS image format is useful and very amenable to automatic processing.

Current ERTS Activities

A number of investigators are engaged in determining the capabilities of current ERTS imagery in the recognition and measurement of land use features. At the Symposium on Significant Results Obtained from the ERTS-1 (Goddard, March 1973), one entire session was devoted to Land Use and Mapping. Of the 27 papers presented at the session, 17 dealt directly with land use, and most of these were concerned with specific areas and locations. A group of these dealt with the Central Atlantic Regional Ecological Test Site (CARETS), indicating a number of ERTS mapping efforts were successful not only in identifying and measuring urban land uses, but also in measuring changes in the time with respect to earlier information. In fact, the most prominent new capability appears to be the detection of land use changes from non-urban (agricultural, etc.) to urban and suburban.

F. C. Westin of South Dakota State University produced a land use and land value map of South Dakota based on ERTS imagery and additional sources.

> "The resulting map...provides information on how buyers value the land in each of the areas. The map is intended for use by revenue officers to equalize land values in the state, by individual buyers and sellers of land and lending institutions as a reference source, as a reference map by those planning road routes, cable lines and pipelines, by conservationists in helping to keep inventories current, by agronomists needing up-to-date information on distribution patterns of crop growth, and by crop-yield forecasters to guide sampling strategy. Scientists at Tulane University used ERTS digital data successfully to classify the city of New Orleans into four environmental classes of urban quality."*

* "Widening ERTS Applications," E.P. Mercanti; Astronautics & Aeronautics, May 1974, pgs. 33, 34, 32.

RMF No. 4.1.2

Professor Robert B. Simpson of Dartmouth College made a land use map of Rhode Island from ERTS images in 48 man hours.*

> "Other land-use planners are also turning to ERTS as the only source of low-cost, accurate, up-to-date information. Land-use inventories are being conducted in several states (Wisconsin, Minnesota, Michigan, and Wyoming) at various levels of classification for use along with other types of information for land and resource management. An example is the use of inventory information in the enforcement of laws concerning wetlands management. At the Univ. of Minnesota, D. Brown and other scientists have set up the inventory in such a way that it can be used to update an operational statewide land management system.
>
> "Urban planners in Los Angeles (S. Raje, R. Economy, and J. McKnight) and in the Detroit suburb of Oakland County, Michigan (Irwin Sattinger and Robert Dillman), are using ERTS data to map and monitor urban growth into surrounding open, agriculture, and recreational areas. In Los Angeles County, Raje has mapped urban boundaries for use in the Federal/State Revenue Sharing Program.
>
> "Pilot land-use mapping from ERTS imagery has delineated natural and cultural features over a 1300-sq-km (500-sq-mi.) area in Columbus/Franklin County, Ohio. This mapping established the fact that natural and cultural features can be accurately mapped at scales in excess of 1:125,000 (Sweet, Wells, and Wukelic).
>
> "ERTS-1 imagery has been applied to the metropolitan areas of Riverside and San Bernadino in Southern California for updating urban land use. In addition, data have also been used to assess the recreational impact of

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* "ERTS-1 Toward Global Monitoring," J.C. Fletcher; Astronautics & Aeronautics, Sept. 1973, pg. 35.

> dune-buggy racing on desert ecologies in Southern California (Bowden and Niellenave). H. Mallon of the Metropolitan Washington Council of Governments has used ERTS imagery to update land-use information in the Washington, D.C. area."*

Current ERTS and associated data processing capabilities allow mapping at levels I and II. The Canada Centre for Remote Sensing in Ottawa has published pictures of urban areas obtained by additional enhancement processing of ERTS images. These pictures show urban details down to individual streets and blocks. It is thus already possible to obtain some level III land clasification features.** Therefore, improved resolution - down to 20 meters, for example - will probably allow virtually all level III mapping from ERS images.

Estimate of ERTS Economic Benefits

The dollar benefits due to savings in mapping costs under this RMF accrue to the agencies performing these operations. They have been aggregated for all Federal and state activities and appear as part of that total in Table 7 in the introduction. Further benefits exist in frequency of update and speed of data acquisition.

* "ERTS-1 Teaching Us a New Way to See," E.P. Mercanti; Astronautics & Aeronautics, Sept. 73, pg. 60.

** "Land Use Classification and Change Analysis Unsing ERTS-1 Imagery in CARETS," R. H. Alexander; Paper L6, Symposium on Significant Results from ERTS-1, Goddard, March 1973.

RMF No. 4.1.3

FAULT ZONE AND LINEAMENT MAPPING

Rationale of Benefits

In some instances there exists uncertainty and dispute about the presence and location of faults. Where mapping is incomplete, or in dispute, development may take place and inordinately high values may be placed on land. When mapping is complete and the threat of earthquake is known, values will fall and it will be recognized that the fault zone has been improperly utilized. Structures might not be designed to withstand quakes, and many lives may be threatened because a large number of people may be located in the zone in unsafe buildings, institutions, schools, etc.

Improved mapping can be expected to prevent future potential loss of life and limb and the value of structures. Benefits obviously extend beyond fault-zone property owners to relatives, friends and even the supporters of organizations worldwide that provide disaster relief.

Federal Government Activities and Responsibilities

The National Oceanic and Atmospheric Administration, the USGS and NASA are gathering measurement data in this area.

Functions of Remote Sensing

Remote sensing by earth resource satellites provides multispectral images in a scale and detail such that fault zones and lineaments can be located and mapped by visual inspection. Current fault mapping by aircraft suffers in that photomontages are now created slowly relative to satellite speed. Thus, shadow changes, occurring during the elapsed time necessary, can obscure faultlines. The unique characteristics of the speed and synoptic coverage of the satellite can virtually eliminate this problem. A fault which may not be seen in summer because of foliage cover, for example, may appear clearly in a winter picture. Photographs taken when the ground is snow-covered provide improved information on lineaments, and, therefore, the repeated coverage by satellite can be of considerable advantage.

Economic and Technical Models for Estimating Benefits of Remote Sensed Data

Minimum benefits may be computed as the discounted value of added information, i.e., property value losses saved and relief savings. Savings of life and limb are the most important benefits. These economic costs may be measured using the method of Chauncey Starr. Risk of earthquakes to a person living in an earthquake area is about 10^{-10} fatalities per exposure hour. Constant exposure for one year translates to a risk-equivalent annual benefit of about $220 per person with a derivative that yields $1.80 per exposure year per percent change in risk. Benefits from improved knowledge of "real" value of land possible from fault information are modeled in RMF 8.4.1 (Volume X).

Current ERTS Activities

ERTS has shown remarkable ability in detecting subtle features such as lineaments, faults and anomalies. This capability has already proven useful in assessing earthquake probabilities. See RMF 5.1.1, Volume VII for details and documentation.

Estimate of ERTS Economic Capabilities

Significant benefit exists in detecting features which have not shown up on high altitude aircraft mosaics, but these have not been quantified.

RMF No. 4.2.1

PROVIDE CENSUS ESTIMATES - DEMOGRAPHICAL SERVICES

Rationale for Benefits

Accurate demographic information is essential to the planning efforts of both the public and private sectors. For governments, statistical information concerning population size, density and distribution enters into facilities and services planning, tax revenue projections, budget allocations, and legislative decisions. For private concerns demographic information is indispensible to sales efforts, plant location and expansion decisions, personnel services, and other executive planning.

Improvement of both the current census and intercensal demographic estimates by means of more accurate and timely observations can result in improved planning decisions and hence, a benefit to society.

Federal Government Activities and Responsibilities

Under the reorganization act of January 1, 1974, the Bureau of the Census and the Bureau of Economic Analysis were combined to form the Social and Economic Statistics Administration. The SESA is the primary Federal agency for demographic data collection and reporting. The estimated budget for fiscal year 1975 in the current SESA demographic statistics program is $5.2 million. The Housing Act of 1954 (40 USC 461) authorizes the secretary of HUD to provide technical assistance to local government planning agencies through studies or problems relating to urban development.

Function of Remote Sensing

The function of remote sensing in demographic studies is to delineate land use changes to provide inputs to demographic models. Intercensal estimates of population density and distribution may be improved by ERS ability to provide accurate and frequent observations.

Current ERTS Activities

The present ERTS system does not have sufficient resolution to capture the major benefit in this area. Land use measurement as detailed as one-half acre would aid in accurately detecting residential and urban expansion or contraction. A high resolution

RMF No. 4.2.1

thermal infrared sensor might also assist in this function by inferring level of economic activity from thermal radiance.

Estimate of ERTS Economic Capabilities

Possibly significant benefits exist for an ERS satellite system, particularly one with greater capability including higher resolution and a thermal IR sensor.

RMF No. 4.2.2

REGIONAL AND LOCAL LAND USE INVENTORIES

Rationale for Benefits

The utility of keeping regional and local land use inventories lies in 1) environmental concerns; 2) property tax revenue estimation; 3) other community and regional planning. Regional environmental agencies use land use inventories to determine possible need for wildlife preserves, wetland and forest preservation, and industrial zoning. Land use inventories are used for governmental estimates of property tax revenue, given the various tax rates for heavy industry, residential, etc. In the other areas of governmental facility and service planning, zoning regulations and recreational needs, are determined by township committees from land use information. The benefit of improving inventory frequency and accuracy may be found in better governmental planning and regulatory efforts.

Federal Activities and Responsibilities

Land use changes and trends in rural areas are studied by the Department of Agriculture under the Rural Development Act of 1972.

Current ERTS Activities

A study entitled "ERTS-1 Role in Land Management and Planning in Minnesota," has reported on the applications of ERTS-1 imagery to update and refine the detail of land use information in the Minnesota Land Management Information System. The study concludes that successful delineation surface cover is possible, but that each class of cover has its own optimal season(s) for interpretation. The investigators felt that these problems could be reduced with thermal infrared land images, more frequent coverage, or reductions in cloud cover.*

Function of Remote Sensing

The ERS ability to delineate between industrial and residential areas, low density and high density residential areas, and other land uses allows a particular usefulness of ERS in any land use inventory program. As present inventories are usually updated on a yearly or even five year basis, the frequency of coverage provided by ERS would improve the timelines and accuracy of existing land use inventories.

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* Sizer, Joseph E. and Brown, Dwight, "ERTS-1 Role In Land Management and Planning in Minnesota", from Third Earth Resources Technology Satellite-1 Symposium, Volume I (U.S. Government Printing Office, 1974), p.341-350.

RMF No. 4.2.2

Estimate of ERTS Economic Capabilities

Significant benefit potential exists for ERTS in this function. EarthSat has documented a study of benefits for land use information at the State level (see Table 5, page 1-12). Demand for this information at levels smaller than the State is so diffuse that it is very difficult to quantify.

RMF No. 4.2.3

LAND USE CHANGE STATISTICS

Rationale for Benefit

Land use change statistics are currently being used by governmental agencies to determine and predict the course of urban and suburban development, and its impact on wildlife and farmland areas. The use of these statistics by legislators has an impact on zoning regulations, environmental land use laws, and facility planning.

Function of Remote Sensing

Land use change statistics on the local level are presently gleaned from current land use inventories (see RMF 2.4.2). In those areas where land use inventories are not kept for reasons of expense and lack of trained manpower, the startup costs of establishing an expensive inventory system can be avoided by using ERS imagery at frequent intervals.

Current ERTS Activities

The Dartmouth College Project in Remote Sensing which has released a study entitled, "Evaluation of ERTS-1 Data for Acquiring Land Use Data of Northern Megalopolis," concludes "that it is completely practical to compile an 11 category land use map for a state or group of states utilizing unenhanced ERTS-1 imagery and conventional manual photo interpretaion techniques."*

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made, however, significant benefits are evidenced through a demand for State, regional and local land use data.

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* Simpin, Lindgren, and Goldstein, "Evaluation of ERTS-1 Data for Acquiring Land Use Data of Northern Megalopolis". Third Earth Resources Technology Satellite Symposium, Volume I, (U.S.Government Printing Office, 1974), p.386.

RMF No. 4.2.4

MONITOR LAND MOVEMENTS - SAND DUNES, WETLANDS, ETC.

Rationale for Benefits

Accurate monitoring of sand dune movements is important to transportation in desert areas. In the short term, monitoring sand dune movements could allow a more efficient scheduling of road and rail maintenance efforts. Over a longer period of time a record of sand dune movements could pinpoint areas of frequent activity. These areas could be avoided in future road-building projects.

Monitoring wetland movement has considerable importance to sound ecological management of coastal and lake area wetlands. Loss of wetland areas due to natural or manmade causes can radically change wildlife breeding habits, and therefore affect the survival of many species.

Function of Remote Sensing

In the monitoring of sand dune movement, an ERS system could be very effective due to its ability to scan remote desert expanse quickly, accurately, and cheaply. Wetland movement could also be monitored in remote areas on a timely basis.

Estimate of ERTS Economic Capabilities

Benefit potential in cost savings exists for this function but have not been quantified.

RMF No. 4.4.1

SELECTION OF FEDERAL AND STATE PARKS AND RECREATION AREAS

Rationale for Benefits

Benefits come from the increased use of recreational areas by tourists nd neighborhood residents. A better selection of the recreation sites will enhance their aesthetic value, hence attract more users (primary benefit). The service industry along the recreational sites will be the recipient of the secondary benefit as a result of increased spending by users.

From the macro point of view, parks and recreational areas serve as the buffer zone between the industrial section and the residential section. Thus, a further benefit will accrue to the society by placing parks and recreational areas which will properly separate future industrial areas from residential areas.

Federal Covernment Activities and Responsibilities

National Wilderness Preservation System, 1964 (P.L. 88-577) -"the Secretary of Agriculture shall review as to its suitability or non-suitability for preservation as wilderness each area in the national forest classified on the effective data of this Act as primitive . . ."

Outdoor Recreation Act (P.L. 88-29) -"the Secretary of the Interior is authorized to prepare and maintain a continuing inventory and evaluation of outdoor recreation needs and resources."

Function of Remote Sensing

Remote sensing offers a fast and inexpensive means for inventorying forest and open space and their relationship to urban centers and physical features such as lakes, rivers, and mountains.

Current ERTS Activities

ERTS-1 has been shown to possess sufficient resolution capability for this activity. All Level I categories can be differentiated.

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

RMF No. 4.4.2

LOCATION OF NEW TOWNS AND OTHER DEVELOPMENTS

Rationale for Benefits

In highly urbanized areas such as the Middle Atlantic States, a phenomenon has developed which threatens orderly land use. Small housing developments (e.g., 20-30 homes), shopping centers, etc., are appearing so rapidly that state planners cannot keep up with them. Their effects on the environment cannot be properly assessed because the developments are frequently unknown to the planners until the damage has already occurred. The problems created by improper development involve a wide range of difficulties. In one New Jersey area, water drainage was affected by land development with the result that an area which had never flooded in the past now suffers frequent flooding. Sometimes the new developments cause overloads of utilities, transportation facilities, water supplies, and sewage disposal facilities. Other problems include erosion due to stripped vegetation, destruction of desirable wildlife habitat and pollution of water supplies.

Federal Government Activities and Responsibilities

Federal activities are authorized on mandate by the following statutes: Water Resources Planning Act (42 USC 1962A-1)- the Water Resources Council is directed to maintain a continuing study of the adequacy of water supplies necessary to meet the water requirements of each water resource region in the U.S., and the National Flooding Insurance Act of 1968 (see RMF 4.1.2).

Function of Remote Sensing

Remote sensing offers frequent update capabilities to determine urban or residential sprawl and housing development trends and their effects on the local ecology. Recent information provides the maximum amount of time to deal with problem situations before resources are committed.

Estimate of ERTS Economic Capabilities

Significant benefit exists for State and local planners, but has not been estimated.

RMF No. 4.4.3

ALLOCATION OF LAND FOR HIGHWAYS AND OTHER RIGHTS-OF-WAY

Rationale for Benefits

In the past, highway alignment was generally decided largely on engineering considerations; that is, minimizing a combination of costs and road length, subject to certain highway construction standards and specifications. Other considerations, such as the environmental, social, industrial and general economic consequences of highway routing were ignored, for several reasons: statutory and budgetary (no funds available either for developing the appropriate data or for the cost added due to selecting a routing more expensive than the minimum); the difficulties, both conceptual and practical, in obtaining the additional data and in quantifying it; and the lack of a vehicle for the expression of the interested parties affected.

The damage caused by this narrow-minded approach can be readily observed by looking at the effects of some interstate highway routings, especially through urban and suburban areas. This type of layout would not be acceptable, or even legal, today: groups affected are increasingly vocal and will make themselves heard through various political and publicity means, plus present Federal law requires a statement of environmental impact for any project of this kind.

The following pre-ERS case history provides a good illustration of the potential value and contribution of ERS data to problems of land use-location-allocation for highway and other right-of-way alignments.

A prominent urban and regional planner has developed a method to optimize or improve highway layouts and alignments.* It consists of drawing up a series of thematic maps of the region under consideration on transparent plastic sheets. The darker or denser the color of specific areas on a particular thematic map, the less desirable that spot is for purposes of highway routing. For example, slope is undesirable; therefore a map with shading proportional to local slope at each point is prepared. Some of these maps represent physical characteristics, such as forest cover, soil conditions, etc. Others may represent such considerations as land values or historic values. These transparencies are then superimposed, and the most suitable areas for highway location emerge. Various alignments are then tried out until the "best" one is selected

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* "Design with Nature", Ian McHarg, Doubleday, 1969; pg. 35 et seq.

and agreed on. This method not only allows the comparison of various alignments, but enables planners - and other interested parties - to test and appreciate the influence of each factor considered. At this point the method is still largely qualitative in the aggregate.

McHarg describes two specific practical applications of his qualitative method, one related to the routing of highway I-95 through central New Jersey, and the other concerning the location of Richmond Parkway through Staten Island, New York.*

> Interstate Highways should maximize public and private benefits:
>
> 1. by increasing the facility, convenience, pleasure and safety of traffic movement.
>
> 2. by safeguarding and enhancing land, water, air and biotic resources.
>
> 3. by contributing to public and private objectives of urban renewal, metropolitan and regional development, industry, commerce, residence, recreation, public health, conservation and beautification.
>
> 4. by generating new productive land uses and by sustaining or enhancing existing ones.
>
> Such criteria include the orthodoxies of route selection, but place them in a larger context of social responsibility. The highway is no longer considered only in terms of automotive movement within its right-of-way, but in context of the physical, biological and social processes within its area of influence.
>
> The highway is thus considered as a major public investment, which will affect the economy, the way of life, health and visual experience of the entire population within its sphere of influence. It is in relation to this expanded role that it should be located and designed....

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* Ibid., pgs. 32 and 35.

It is important to observe that the reader parallels the experience of the author at the beginning of the study. The method was known but the evidence was not. It was necessary to await its compilation, make the transparent maps, superimpose them over a light table and scrutinize them for their conclusion. One after another they were laid down, layer after layer of social values, an elaborate representation of the Island, like a complex X-ray photograph with dark and light tones. Yet in the increasing opacity there were always lighter areas and we can see their conclusion.

The implications of the method for the demand and utilization of ERS-type data are significant: several of the thematic maps can be obtained from ERS data, probably automatically. In addition, superposition of these (and others prepared by other methods) is easily done automatically by the methods and devices developed for processing ERS data, with the added possibility of easily varying and adjusting the relative weights of the individual factors and performing sensitivity analysis.

The benefits of this kind of integrated approach to the highway layout-allocation-design problem are quite apparent. At the same time they are very diffuse and difficult to quantify and spread out over a very long time period. Ideally the benefits of good versus not-so-good planning and layout can only be gauged by comparing the effects of a given actual allocation with the potential "what-if" consequences of an alternate plan, both over a correspondingly long interval. But these benefits are very diffuse. That is, they accrue in widely varying amounts to a large variety of users and interested parties (highway users, both private and business, their suppliers and customers, industries in the area, land owners, taxpayers, etc.); plus the minimized losses or disbenefits to those people adversely affected by the layout (and there will always be some of these, regardless of the final routing).

But, even after having resolved - in some fashion - the question of what the actual benefits of better highway alignment, another problem arises: that of determining what part of the benefits due to better planning accrue to ERS technology, the real subject of this study.

RMF No. 4.4.3

Federal Government Activities and Responsibilities

Although the Federal Government, through the Interstate Highway System, has a very large stake in highway layout, the planning and alignment of roads under this program is left entirely to the States themselves. The States must plan and build to certain standards, which the Federal Government then must verify. No Federal statutory remote sensing activity appears to exist at present. However, it is very likely that, as ERS imagery becomes more widely distributed, it will be used for verification and inventorying purposes. This would also apply to high-tension power line and pipeline rights-of-way, subject to FPC supervision, and rail transportation.

Non-Federal Activities

The task of laying out and building highways and roads falls to State and local authorities. Current standard ERTS images don't have sufficient contrast or detail to show roads clearly without enhancement, but there exist processing techniques which will show roads using existing remotely sensed data. Thus, State and local activities will probably build up very quickly in the near future.

Function of Remote Sensing

Satellite sensing provides an opportunity for obtaining information quickly and at low cost. Image data are easily put in the form described by McHarg and should prove highly useful when used in this manner.

Estimate of ERTS Economic Capabilities

For this function, ERTS cannot provide improvement in capability over high altitude aircraft. Thus, any benefits accruing to ERTS come in the form of cost savings. Estimated benefits for this function are included in the cost effectiveness figures of Part II.

RMF No. 4.4.4

SELECTION OF AREAS FOR LAND RECLAMATION

Rationale for Benefits

Land reclamation increases the supply of the productive land for residential, recreational, and industrial use. Given the areas of refuse land, the criterion for selection is the market value of a tract of reclaimed land, i.e., the higher the prospective market value, the sooner the reclamation. By using this criterion, society obtains the most efficient selection of land for reclamation.

Function of Remote Sensing

Remote sensing offers detection and assessment of potential reclamation areas. Distributed areas can be monitored to determine if they are suffering or causing increasing damage. Most valuable areas can be determined in context with population centers or natural resources. Monitoring of reclamation progress can frequently be done using satellite imagery.

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

RMF No. 4.4.5

SITE LOCATION OF AIRPORTS AND OTHER MAJOR TRANSPORTATION MODES

Rationale for Benefits

The benefit of optimal location of major transportation modes is to reduce the cost of transportation between population centers, and to minimize the cost of environmental damage such as airport noise and harbor pollution.

The efficient mass transportation system for urban centers, such as subway and bus lines, will yield an additional benefit in the form of a shortened travel time.

Federal Government Activities and Responsibilities

The primary agency active in this area is the Department of Transportation.

Function of Remote Sensing

Using the technique of McHarg (RMF 4.4.3), satellites can provide most of the primary data for this function at low cost.

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

RMF No. 4.5.1

PROTECTION OF AGRICULTURAL AND FOREST LANDS

Rationale for Benefits

Conservation of agricultural and forest lands is crucial to both the productive and recreational interests of the nation. Due to population growth, housing sprawl, and industrial development, the abundance of open arable land and commercial forests has dwindled. Although that which has been lost in farm acreage generally has been made up with productivity gains, increased domestic and foreign demand has recently forced cultivation of previously untilled lands. In addition to the loss of commercial forest areas, non-commercial timber land areas valued as sanctuaries of wildlife and for recreational purposes are also being lost. Protection of these areas by law and enforcement will result in substantial productive and recreational benefits.

Federal Government Activities and Responsibilities

By direction of the Clarke-McNary Act of 1935 (16 USC 567A), the Secretary of Agriculture is authorized to acquire forest lands to be managed by the states as state forests. Acquisition of new forest lands includes land use determination. The Agricultural Research Act of 1935 authorizes the Secretary of Agriculture to conduct research relating to the conservation, development, and use of land, forest, and water resources for agricultural purposes.

Function of Remote Sensing

An ERS system can assist protection of agricultural and forest lands by (1) monitoring land use changes in these rural areas and thereby contributing to zoning legislation, (2) enforce existing land use regulations. ERS capability of frequent and accurate observation of remote rural areas can contribute significantly here.

Current ERTS Activities

ERTS-1 has shown high accuracy in inventorying Level-I categories.

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

RMF No. 4.5.2

PROTECTION OF WILDERNESS AREAS

Rationale for Benefits

Wilderness areas provide aesthetic and recreational values that can be recovered only over a very long time once they are lost to the abuses of mankind or to the preventable (in some instances) ravages of nature. Loss of wilderness also upsets the ecosystem through the destruction or rearrangement of flora and fauna; many species may become extinct and man's food supply may be impacted. The benefits of wilderness protection accrue to the present and future generations of mankind in general.

Federal Government Activities and Responsibilities

Under the National Wilderness Preservation System of 1964, (P.L. 88-577), the Secretary of Agriculture is required to file a map and legal description of all wilderness areas. The Secretary must also review and report on each area as to its suitability or non-suitability for preservation as a wilderness area. By direction of the Outdoor Recreation Act of 1963 (P.L. 88-29), the Secretary of the Interior is authorized to prepare and maintain a countinuing inventory and evaluation of outdoor recreation needs and resources of the United States. The Fish and Wildlife Act of 1956 (16 VSC 742) requires the Secretary of the Interior to, among other things, take such steps as may be required for the development, management, advancement, conservation, and protection of wildlife resources.

Function of Remote Sensing

See RMF No. 4.5.1

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

RMF No. 4.6.1

MAP SINK, LANDSLIDE AND OTHER HAZARDOUS AREAS AND ASSESS DAMAGES

Rationale for Benefits

The mapping of frequency and severity of sink holes and landslides allows proper assessment of land suitability and land values within an area. In remote areas, steps can be taken to prevent erosion. Mapping of flood plains will help insure proper protective procedures.

Federal Government Activities and Responsibilities

In the Flood Control Act of 1960, as Amended (33 USC 709a) the Army Corps of Engineers is authorized to compile and disseminate information on identification of areas subject to flooding and general criteria for guidance in the use of flood plain area.

The Watershed Protection and Flood Protection Act, (16 USC 1001-1009) authorizes the Federal government to conduct investigations and surveys as may be necessary to prepare plans for flood prevention or the conservation, development, utilization and disposal of water.

Function of Remote Sensing

Satellite sensing offers the ability to rapidly map flood areas to determine the extent of the flood plains. Such mapping can be done at low cost.

Current ERTS Activities

Flood plain features such as natural and artificial levee systems, upland boundaries, vegetation and soil differences, flood alleviation measures, and land use and agricultural patterns are easily identified through tonal differences on ERTS-1 imagery.*

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

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* Rango, "ERTS-1 Flood Hazard Studies in the Mississippi River Basin," Third ERTS Symposium, December 1973.

RMF No. 4.6.2

ASSESS IMPACT OF EARTHQUAKES AND VOLCANIC ERUPTIONS

Rationale for Benefit

Assessment of damage to urban areas due to earthquake and volcanic eruption is necessary to determine the relief needed. An accurate history of such events allows preventative measures to be taken and could perhaps facilitate prediction and preparation.

Function of Remote Sensing

Satellites offer a capability for providing damage assessment in near real time. Historical data can be obtained at low incremental cost.

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

RMF No. 4.9.1

MANAGE FEDERAL REVENUE SHARING PROGRAMS

Rationale for Benefits

Federal revenue sharing programs must be managed in order to (1) allow a reasonable return either human o. economic, on federal tax dollars, (2) avoid the possible disruptive regional effects of an outdated revenue sharing program. The effective management of these programs would include frequent assessment of the demographic and land use changes within the impacted region. Accurate evaluation of a program's utility could lead to a more optimal ordering of priorities, including cuts in funding for areas of comparatively lesser need. As revenue sharing funds are reallocated to their highest valued uses, the entire nation will realize a better return on federal tax dollars. Effective management of federal revenue sharing programs can also avoid overspending of federal funds in areas where the problem in need of revenue sharing was not correctly defined. This avoidance can prevent possible disruptive regional effects.

Federal Government Activities and Responsibilities

As established by Public Law 92-512 (86 Stat. 919) a trust fund was established with the Treasury Department to provide "general revenue sharing payments to localities for defined high-priority expenditures and payments to the states to supplement their revenue sources."* For fiscal year 1975, the estimated budget for this fund is 6.2 billion dollars.

Function of Remote Sensing

An ERS system can assist in the management of Federal revenue sharing programs by providing accurate and frequent updating of demographic and land use change statistics. These objective inputs can improve project evaluations, and detect harmful trends. For a discussion of ERS abilities in statistical observation see RMF No. 4.2.1– 4.2.4.

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

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* Budget of the U.S. Government FY-75 (USGPO, 1974) p. 752.

RMF No. 4.9.2

REGULATE LAND USE IN AREAS OF CRITICAL ENVIRONMENTAL CONCERN

Rationale for Benefits

Effective land use regulation of wetland areas, megalopolis, and other critical environmental areas of the nation is particularly important to the economic future of the United States. The three major population centers of the country, San Francisco-San Diego, Chicago-Pittsburgh and Boston-Washington, are currently experiencing environmental crisis. Water, air, and land pollution can at least be alleviated by regulated changes in land use. For example, solid waste disposal could be zoned away to less critical areas; air polluting industry could be required to locate downwind from population centers. Regulation of land use through legislation in the megalopolis will result in both health and productivity benefits for the region. Wildlife preservation is one goal behind land use regulation of wetland areas. Regulation of land use in these area will hopefully protect many already endangered species.

Function of Remote Sensing

Regulation of land use could be assisted by an ERS system in the detection of both illegal land usage and in areas in need of land use regulation. For a discussion of the function of ERS in the detection of land use change, see RMF 4.2.3.

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

RMF No. 4.9.3.

REGULATE LAND DEVELOPMENT PROJECTS

Rationale for Benefits

Zoning laws often set limits on housing density, industrial plant size and require certain areas be left undeveloped. The regulation of these areas allows community facility and service planning, projection of tax revenue and an overall condition of planned growth. Regulation of land development primarily benefits the community involved and secondarily the region's planning of transportation networks, energy needs, natural resource needs and the like.

Function of Remote Sensing

An ERS system could assist regulation of land development by giving governmental enforcement agencies frequent observations of the areas in question.

Estimate of ERTS Economic Capabilities

No estimate of benefits has been made.

RMF No. 4.9.4

MANAGE AND PLAN FEDERAL, STATE AND LOCAL TAXATION

Rationale for Benefits

In recent years, the property tax has assumed increased importance in public finance. It has become particularly burdensome in the heavily populated areas of the United States. Rapid population growth and migration to the cities have put severe pressure on the property tax— the major source of revenue for local government— to finance new schools, primarily, but also other local functions, e.g., welfare, police and fire protection, sanitation, streets, sewers and courts. The nation's cities have been hit the hardest, at least partly because a large fraction of their services must be provided for nonresidents. As a result, those people who are relatively well-off financially have abandoned the cities for the suburbs. Industrial firms have also fled the cities to avoid the excessive tax burden leaving behind those people who are least able to bear it. These shifts have been chaotic: mass transportation networks move into the cities— *not* to the new plants. Plants are of horizontal construction, utilizing large tracts. Urban sprawl, leap-frogging and land speculation have destroyed open space. The attempt to keep taxes low in the suburbs has resulted in large tract zoning (1/2 acre to several acres).

These movements are interfering with the hydrologic cycle, posing flood threat from run-off changes, impoverishing the cities and causing unemployment due to labor immobility. Orderly development is being severely hampered. Highways and roads are replacing mass transit, adding to congestion and pollution problems.

Proper management of Federal, State and local taxation, which can at least halt the trend and begin some reversal, will benefit all citizens who reside in, work in or travel to heavily populated areas.

Function of Remote Sensing

The function of an ERS system in the management of taxation lies in the system's ability to aid in the preparation of timely land use inventories. With current inventories, estimations of tax revenues on a Federal, State, or local level can be made easily.

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Estimate of ERTS Economic Capabilities

Significant benefits exist to lower level governmental agencies, but have not been quantified.